

ANESTHESIA PROVIDERS' KNOWLEDGE AND UTILIZATION OF A
QUANTITATIVE MONITOR FOR NEUROMUSCULAR FUNCTION RECOVERY

by

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As members of the DNP Project Committee, we certify that we have read the DNP project prepared by Diana Lynn Willis, titled Anesthesia Providers' Knowledge and Utilization of a Quantitative Monitor for Neuromuscular Function Recovery and recommend that it be accepted as fulfilling the DNP project requirement for the Degree of Doctor of Nursing Practice.

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TABLE OF CONTENTS

LIST OF FIGURES	5
ABSTRACT.....	6
INTRODUCTION.....	8
Background	8
Key Concepts.....	9
Peripheral Nerve Stimulator.....	9
Qualitative Nerve Stimulator.....	9
Quantitative Nerve Stimulator	9
Acceleromyography Technology	10
Kinemyography Technology	10
Nondepolarizing Neuromuscular Blocking Drugs.....	10
Purpose, Aims and Objectives	10
Project Question.....	11
Theory and Framework	11
Theory of Planned Behavior	11
Promoting Action on Research Implementation in Health Services.....	12
Synthesis of Evidence.....	15
Strengths, Weaknesses and Gaps	17
METHODS	18
Design	18
Setting.....	19
Participants.....	19
Data Collection	19
Ethical Considerations.....	20
Data Analysis.....	20
RESULTS	21
Demographics.....	21
Responses to Specific Project Questions.....	21

TABLE OF CONTENTS – *Continued*

Project Question 1	22
Project Question 2	22
Project Question 3	23
Project Question 4	24
Project Question 5	24
Project Question 6	25
Project Question 7	25
DISCUSSION	26
Relationship of Results to Project Aims, Theory and Framework	26
Impact of Results on Practice Change	27
Strengths and Limitations	27
Dissemination and Implications for Future Practice	28
DNP Essentials	28
 APPENDIX A: APPRAISAL OF EVIDENCE.....	30
APPENDIX B: PRETEST SURVEY.....	37
APPENDIX C: EDUCATIONAL POWERPOINT PRESENTATION	39
APPENDIX D: POSTTEST SURVEY	45
APPENDIX E: RECRUITMENT EMAIL	47
APPENDIX F: DISCLOSURE FORM.....	49
APPENDIX G: THE UNIVERSITY OF ARIZONA INSTITUTIONAL REVIEW BOARD APPROVAL LETTER.....	52
APPENDIX H: EXECUTIVE SUMMARY	55
REFERENCES	57

LIST OF FIGURES

<i>FIGURE 1.</i>	Theory of planned behavior model.	12
<i>FIGURE 2.</i>	Adaptation of PARIHS framework.....	15
<i>FIGURE 3.</i>	Years of experience of respondents.	21
<i>FIGURE 4.</i>	Respondents methods of determining status of neuromuscular blockade.	22
<i>FIGURE 5.</i>	Respondents perception of the best method of neuromuscular assessment.....	23
<i>FIGURE 6.</i>	Respondents perception of postoperative residual paralysis/weakness.	24
<i>FIGURE 7.</i>	Respondents rationale for administration or omission of reversal agents.	25

ABSTRACT

Anesthesia providers have the cardinal responsibility to ensure that patient safety is maintained throughout the perioperative period. Neuromuscular blocking drugs are frequently administered to patients during surgery. Residual weakness at the end of surgery can place patients at risk for critical respiratory events. There are several ways to monitor a patient for recovery of neuromuscular function. The definition of recovery is defined as a Train-of-four ratio greater than 0.9 and can only be assessed using a quantitative peripheral nerve stimulator. The aim of this project was to increase knowledge and utilization regarding the use of quantitative monitors to assess neuromuscular function. Train-of-four (TOF) is the most widely used means of nerve stimulation assessment by delivering four equal stimuli; a comparison is made of the four responses (Nagelhout, 2014). When partial paralysis is present a fade in response occurs from twitch one to twitch four; the difference in twitch response is used to calculate the train-of-four ratio (TOFR) (Nagelhout, 2014). Anesthesia providers ($n = 80$) at two student clinical rotation sites in Maricopa County Arizona were sent a pretest survey, educational presentation, and posttest survey to compare knowledge and attitudes, awareness of techniques, and practice habits regarding neuromuscular monitoring; the final number of respondents was 12. The results of this project concluded that most providers assess neuromuscular function using a conventional peripheral nerve stimulator ($n = 11$). After reviewing the educational presentation, most anesthesia providers agreed that postoperative residual paralysis/weakness is a problem ($n = 10$) and the best method to assess neuromuscular function recovery and to guide reversal agent administration is to use a quantitative nerve stimulator ($n = 9$). Many providers ($n = 7$) stated they were unlikely to change their practice and cited inadequate resources as a barrier ($n = 9$). In

conclusion, quantitative monitoring for neuromuscular function recovery may feasibly become the new standard of care with further education and access to the resources necessary to accomplish that.

INTRODUCTION

Background

Nondepolarizing neuromuscular blocking drugs (NMBD) are used in the operating room for a variety of surgical procedures when muscle relaxation is crucial to patient safety. Incomplete recovery from the effects of these medications occur in as many as 40% of cases and patients are susceptible to developing respiratory complications such as hypoxemia, hypoventilation, airway obstruction, and apnea (Kiekkas, Bakalis, Stefanopoulos, Konstantinou, & Aretha, 2014). Critical respiratory events place the patient at risk for prolonged recovery, re-intubation, pneumonia, hemodynamic instability, and unexpected admission to the intensive care unit (ICU) (Kiekkas et al., 2014). Incomplete recovery from neuromuscular blockade is defined as a train-of-four ratio (TOFR) less than 0.9 (Lien & Kopman, 2014). Currently, peripheral nerve stimulators are the gold standard used to obtain a train-of-four (TOF) reading. The most widely used peripheral nerve stimulator provides qualitative data that relies on the examiners subjective visual or tactile assessment of the patient's muscle response to the stimulus to determine the presence or absence of fade by comparing the size of the fourth twitch to the size of the first twitch. There is a risk of variability in assessment between examiners. Most examiners are unable to detect fade through subjective assessment when the TOFR reaches 0.4 (Brull & Kopman, 2017). A TOFR of 0.7 is associated with significant weakness (Lien & Kopman, 2014). Peripheral nerve stimulators that use acceleromyography technology quantitatively measure the muscle response to TOF stimulation (Lien & Kopman, 2014) and are reported to assist providers more reliably prevent residual neuromuscular paralysis. Acceleromyography monitoring is accomplished by attaching a piezoelectric sensor at the thumb and measures the rate of angular

acceleration in response to nerve stimulation, the size of the acceleration output is quantified into a TOFR (Dilos & Eisenkraft, 2014). The goal is to accomplish a TOFR of greater than 0.9 as a determinate of full recovery of neuromuscular function. Small degrees of residual neuromuscular relaxation, defined as a TOFR between 0.8 and 0.9, impairs the ability to swallow and increases the risk of pulmonary aspiration (Unterbuchner, 2018).

Key Concepts

The key concepts of this project are to provide education to anesthesia providers regarding the use quantitative peripheral nerve stimulators to influence practice change in monitoring for depth of neuromuscular blockade with the administration of non-depolarizing neuromuscular blocking drugs.

Peripheral Nerve Stimulator

The *peripheral nerve stimulator* is a neuromuscular monitor that delivers a series of electric shocks or impulses through electrodes applied to the patient's skin near a nerve (Nagelhout, 2014).

Qualitative Nerve Stimulator

A *qualitative nerve stimulator* permits a provider to assess the response to nerve stimulation by visual and tactile assessment;

Quantitative Nerve Stimulator

A *quantitative nerve stimulator* couples the stimulator to a displacement transducer that monitors movement with nerve stimulation and provides a quantifiable value known as a Train-of-four ratio (Nagelhout, 2014). Acceleromyography (AMG) and kinemyography (KMG) are technologies that are used for quantitative neuromuscular monitoring.

Acceleromyography Technology

Acceleromyography technology is employed by attaching a piezoelectric sensor the thumb and measures the rate of angular acceleration in response to nerve stimulation, the size of the acceleration output is quantified into a TOFR (Dilos & Eisenkraft, 2014).

Kinemyography Technology

Kinemyography technology utilizes a piezoelectric sensor strip that is incorporated into a U-shaped device, a mechanosensor, that is placed between the thumb and index finger (Dilos & Eisenkraft, 2014). Movement of the thumb in response to nerve stimulation produces a redistribution of electrical charge across the piezoelectric sensor, the voltage produced is measured and quantified as a TOFR (Dilos & Eisenkraft, 2014).

Acceleromyography and kinemyography are reliably interchangeable to assess recovery of neuromuscular block (Ezer, Bezen, Saracoglu, Ozata, & Sengul, 2014).

Nondepolarizing Neuromuscular Blocking Drugs

Nondepolarizing neuromuscular blocking drugs bind to presynaptic and postsynaptic acetylcholine receptors. The binding of these drugs to presynaptic acetylcholine receptors prevents acetylcholine from being made available for release to sustain a muscle contraction with nerve stimulation (Naguib, 2015). These drugs can lead to intense muscle tone relaxation commonly referred to as paralysis. Muscle twitch depression results from the binding of NMBD to postsynaptic acetylcholine receptors (Naguib, 2015).

Purpose, Aims and Objectives

The purpose of this Doctor of Nursing Practice (DNP) project is to improve neuromuscular function assessment practices of anesthesia providers that are congruent with

current evidence-based practice. The aim is to increase knowledge and utilization regarding the use of a quantitative Train-of-four monitor for neuromuscular function recovery. The objective is to identify current evidence-based recommendations in the literature for the use of acceleromyography technology to assess neuromuscular function after patients have received nondepolarizing neuromuscular blocking drugs during surgery.

The stakeholders for this project are the anesthesia department leaders and the anesthesia staff that chose to participate in the survey and educational presentation. Involuntary stakeholders are represented by the patients who require neuromuscular blockade for a surgical procedure. Patients will presumably benefit from a more reliable monitoring technique to assess neuromuscular function recovery that assures improved safety and reduces the occurrence of critical respiratory events in the perioperative period.

Project Question

How do anesthesia providers (P) participating in an educational presentation regarding the use of acceleromyography technology (I) perceive they will change their neuromuscular monitoring attitudes and practices (O) following the presentation (T)?

Theory and Framework

Theory of Planned Behavior

The Theory of Planned Behavior suggests that behavior change is influenced by attitude, subjective norms, perceived behavioral control, and behavioral intention (Cornally, 2014). Attitudes result from beliefs about the consequences of a behavior and evaluation of the outcome (Cornally, 2014). The target population for this project, anesthesia providers, may have existing attitudes regarding current practice and not perceive a problem and need for change. Subjective

norms relate to an individual's motivation to comply with the beliefs of others (Cornally, 2014). The influence of other providers may encourage or prohibit changes in assessment practices. Perceived behavioral control pertains to an individual's beliefs to carry out a behavior and encompasses internal (knowledge and ability) and external (tangible obstacles and opportunities) factors (Cornally, 2014). Behavior intention is predicted by attitudes, subjective norms, and perceived behavioral control (Cornally, 2014). This theory was chosen because it involves components of provider behavior that influence practice change.

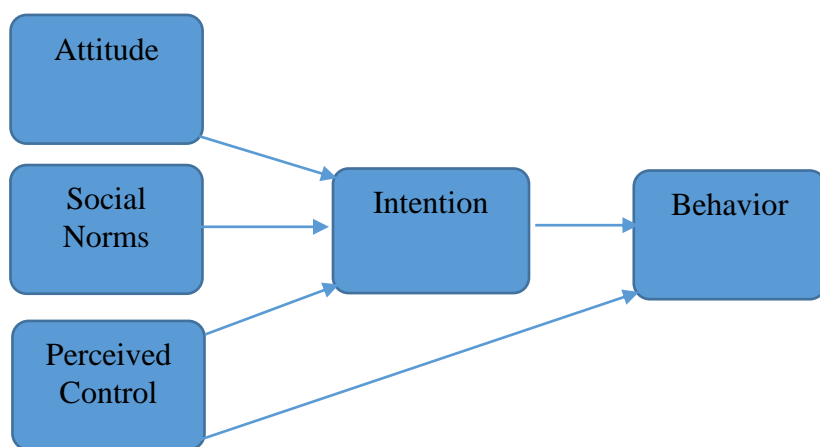


FIGURE 1. Theory of planned behavior model.

Promoting Action on Research Implementation in Health Services

The conceptual framework to operationalize this project is the Promoting Action on Research Implementation in Health Services (PARIHS). The PARIHS framework is used to understand the complex process on how evidence is used for successful implementation into practice with the implicit assumption that relevant research will result in improved outcomes for patients and organizations (Rycroft-Malone, 2013). The framework encompasses three elements: evidence, context, and facilitation. Evidence must be scientifically robust and align with provider

and patient preferences; context refers to an environment where culture and leadership are receptive to change where there are appropriate monitoring and feedback systems are in place; facilitation of change requires input from skilled external and internal facilitators (Rycroft-Malone, 2013).

Evidence is generated from research, clinical experience, provider experience and local context applicability (Rycroft-Malone, 2013). Research evidence must be well conceived, valued, and relevant to the audience (Rycroft-Malone, 2013). Research in the realm of clinical experience must reflect upon the experience and expertise of the audience, and consensus within the group on the relevance and importance of the evidence is essential (Rycroft-Malone, 2013). The local context or organization must value the research as relevant and reflect upon its importance and applicability to practice (Rycroft-Malone, 2013). Most anesthesia providers are unfamiliar with acceleromyography technology and likewise unaware that traditional qualitative peripheral nerve stimulators do not provide an accurate assessment of recovery from neuromuscular paralysis. A thorough search of relevant research will be conducted and synthesized on the topic of acceleromyography use, with a focus on meta-analyses, systematic reviews, and randomized controlled trials. Additionally, research regarding current attitudes and practice habits regarding monitoring for neuromuscular paralysis will be included in the synthesis of evidence. This type of evidence is relevant to the audience as anesthesia providers monitor for neuromuscular paralysis daily and will ideally be valued as a patient safety concern, Patient safety is of great concern and value to every organization or local context where anesthesia services are provided. Anesthesia providers participating this DNP project study will be presented with this high-quality evidence in the form of an educational presentation.

Context is defined in terms of culture, leadership, and evaluation. Culture involves defining values, beliefs, and norms, the organization should promote learning and innovation, and there should be consistency between provider roles and experience to the value of implementing research into action (Rycroft-Malone, 2013). Leadership will focus on effective teamwork, the organizational structure, and an enabling approach to learning, teaching, and managing (Rycroft-Malone, 2013). Evaluation involves feedback on individual, team, and system performance using multiple methods such as clinical performance, economic outcomes, and provider experience with the proposed change (Rycroft-Malone, 2013). The education will be presented to anesthesia providers at facilities receptive to learning the benefits of this newer technology. The goal would be to obtain interest and agreement that acceleromyography is a superior technology for assessment and ultimately lead to a change in culture and practice habits. After the education is delivered to this audience, data regarding changes in attitudes and beliefs about the use of acceleromyography monitors will be analyzed to predict the success of implementing this change into practice.

Facilitation focuses on the purpose, roles, skills, and attributes of all individuals involved in the proposed practice change (Rycroft-Malone, 2013). The facilitator is a student registered nurse anesthetist that will foster credibility in the material being presented. The participants will be anesthesia providers willing to participate in the educational presentation. The information will be presented as power point presentation that will be recorded to allow for flexibility in attendance and participation.



FIGURE 2. Adaptation of PARIHS framework.

Synthesis of Evidence

A literature review was conducted through electronic databases PubMed, and CINAHL. The search terms that were used included acceleromyography, anesthesia, neuromuscular blockade, Train-of-four monitoring, and postoperative paralysis. The search yielded 143 articles. Ten articles were used for the synthesis of evidence and were chosen based on their relevance to acceleromyography monitoring, current practice behaviors and attitudes, and studies conducted within the last 10 years (Appendix A). Meta-analyses, systematic reviews, and randomized controlled trials were preferentially selected due to the high level of evidence that they provide.

Acceleromyography (AMG) monitoring has been shown to accurately detect the presence of residual neuromuscular paralysis that has the potential to result in critical respiratory events in the postoperative period (Bhananker, 2015; Murphy et al., 2011; Murphy et al., 2008; Piccioni, 2014; Sauer, Stahn, Soltesz, Noeldge-Schomburg, & Mencke, 2011). There is wide variability in the current assessment practices of anesthesia providers when neuromuscular blocking drugs

(NMBD) are administered; qualitative assessment of Train-of-four (TOF) response using a conventional peripheral nerve stimulator (PNS), quantitative peripheral nerve stimulators (rare), and physical assessment of neuromuscular function using clinical criteria as the sole evaluation (Naguib et al., 2010; Naguib, Kopman, & Ensor, 2007; Videira & Vieira, 2011). The inadequacy of conventional PNS and physical assessment criteria in detecting adequate recovery from neuromuscular blockade frequently results in clinically significant residual paralysis, and inadequate dosing, timing, or omission of reversal agent administration (Bhananker, 2015; Fortier et al., 2015; Murphy et al., 2011; Murphy et al., 2008; Naguib et al., 2007; Pietraszewski & Gaszynski, 2013; Sauer et al., 2011). Studies that implicate that the use of PNS do not decrease the incidence of residual paralysis in the postoperative period had similar themes that threaten their credibility. The conduct of anesthesia was not kept constant, choice of drugs varied, and the use of peripheral nerve stimulators was not consistent even to guide the dosing of muscle relaxant, and antagonism of neuromuscular blockade was often attempted at a significant degree of paralysis (Naguib et al., 2007). The use of uncalibrated AMG monitoring may overestimate the train-of-four ratio (TOFR) but patients have consistently greater levels of neuromuscular recovery when these monitors are used when compared to qualitative assessment using conventional PNS and clinical criteria (Murphy et al., 2008). The current practice habits of anesthesia providers reflect a lack of awareness of the incidence and severity of postoperative residual paralysis (PORP) and the placement of minimal value on the use of neuromuscular monitoring devices (Naguib et al., 2010; Naguib et al., 2007). Clinicians guide the administration of reversal agents or omit them all together based on criteria that is not quantifiable (total dose of NMBD, timing since last dose of NMBD, absence of fade when using a PNS, and clinical

criteria) often resulting in unacceptable levels of PORP (Fortier, 2015; Murphy et al., 2011; Murphy et al., 2008; Naguib et al., 2007; Naguib et al., 2010; Videira & Vieira, 2011).

Strengths, Weaknesses and Gaps

The strength of appraised literature is that 50% of the evidence was derived from one meta-analysis and four randomized controlled trials. The overall findings of this evidence synthesis prove that quantitative peripheral nerve stimulators are superior to the current practice norms using subjective assessment of a patient's physical status with or without traditional peripheral nerve stimulators. Another strength is that multiple studies derived that many providers are unaware of the problem of residual neuromuscular paralysis thus making this DNP project important to create awareness and influence practice change. The weaknesses to the evidence include the lack of a systematic review or meta-analysis within the last ten years, over half of the studies were conducted outside the United States, and the providers in some of the studies were not blinded to the study group; this may pose a threat to the validity and reliability of the evidence. One of the gaps is the limited availability and use of quantitative monitor that use AMG technology in current practice. Quantitative monitors are not readily available in the United States and when these monitors are accessible, anesthesia providers often opt to use the conventional PNS (Naguib et al., 2010). The results of a survey evaluating management of neuromuscular blockade suggest that anesthesia providers have variable opinions regarding the best way to assess for neuromuscular function recovery (Naguib et al., 2010). Some 90% of U.S. survey respondents agreed that the TOFR should be greater than 80% prior to extubation (Naguib et al., 2010). In contrast, 70% of U.S. respondents believed that the ability to sustain a five second head lift is a reliable indicator of neuromuscular recovery (Naguib et al., 2010). It is

prudent to hypothesize that this may be due to a lack of training on their use or gap in education on the benefits of using quantitative monitoring. The Anesthesia Patient Safety Foundation Collaborative Panel on Neuromuscular Blockade and Patient Safety recommend the use of quantitative monitoring should be used when neuromuscular blocking drugs are administered, and these monitors should be available at all facilities where anesthesia care is delivered (Murphy, 2018).

METHODS

Design

This project was conducted using a pretest email survey (Appendix B), followed by an educational PowerPoint presentation (Appendix C) and posttest (Appendix D). Project material was sent to anesthesia providers by the head of the anesthesia department at each facility that participated. Potential participants were sent a recruitment email, disclosure form, links to the pretest/posttest surveys, and the PowerPoint presentation. The PowerPoint presentation included information about the incidence of PORP, current practice standards, monitoring techniques, current practice habits, benefits of quantitative monitoring, and reversal agent administration. The entire length of the presentation was 18 slides including the title and reference slides. The pretest and posttest survey each had seven questions. The use of email allowed for a larger sample size from multiple diverse facilities. This DNP project compared knowledge and attitudes, awareness of techniques, and practice habits regarding neuromuscular monitoring in the perioperative period before and after receiving an educational training on the use of quantitative peripheral nerve stimulators. This design does not require randomization or a control group and is capable of measuring change in health-related outcomes after an intervention

(Rouen, 2017). The pretest/posttest was appropriate to assess how the intervention will influence caregiver attitudes and behaviors.

Setting

This project was implemented at two University of Arizona affiliated medical centers in Maricopa County, Arizona.

Participants

A convenience sample of 80 anesthesia providers with the title of physician anesthesiologist, certified registered nurse anesthetists (CRNA), and student registered nurse anesthetists (SRNA) were the participants for this project. The final number of participants was 12 and consisted of all CRNA providers.

Data Collection

Approval from the Institutional Review Board (IRB) at the University of Arizona was obtained and met the requirements for minimal risk research (Appendix G). Data was collected using a pretest/posttest method. The survey period started on April 15, 2019 and closed on April 21, 2019. Participants were asked about their current practice habits, perceived incidence of residual neuromuscular paralysis, opinions on monitoring methods, and reversal agent administration practices. This was accomplished using multiple-choice and Likert scale type questions for a total of seven questions for each survey. The Likert scale questions were five-point scale questions ranging from strongly agree to strongly disagree for the perceived incidence of PORP and very likely to very unlikely for the likelihood to change future practice habits. The posttest included the same questions about current practice habits, perceived incidence of residual neuromuscular paralysis, opinions on monitoring methods, and reversal

agent administration practices. All points of data collection were obtained immediately before and after the intervention. Data regarding role as an anesthesia provider and years of experience was collected for demographic purposes. The posttest included questions that evaluated the participants' likelihood to change their practice, if needed, and to assess any barriers to practice change.

Ethical Considerations

This project did not involve patients or vulnerable populations. Respect for persons was addressed by allowing participant autonomy and respect of their privacy. Participation in the educational information was voluntary. Informed consent was obtained, and pre-test and post-test data will be anonymous. The fundamental principle of beneficence is “do no harm” (Department of Health, Education & Welfare, 1979). Beneficence was addressed in the very nature of this project by improving patient safety with a more accurate way to monitor patients for residual neuromuscular paralysis to guide anesthesia providers' care of patients. There were no risks involved with participating in an educational training. Justice was maintained by allowing voluntary participation in the educational training and the recruitment of anesthesia providers to participate may indirectly benefit patients through improved safety.

Data Analysis

Data was analyzed using the Statistical Package for the Social Sciences (SPSS) software using the Wilcoxon signed rank test. The Wilcoxon signed rank test is used to compare two sets of scores from the same participant; it investigates a change in score from one point in time to another after an intervention has taken place (Laerd Statistics, 2018). Descriptive statistics quantitatively describe the key features of collected data, it aims to summarize the actual sample

being studied, and does not require a control for comparison (Kellar & Kelvin, 2013). This type of analysis is helpful to compare changes in knowledge, attitudes towards quantitative monitoring, and perceived changes in practice habits.

RESULTS

Demographics

Project materials were sent to 80 anesthesia providers at two University of Arizona nurse anesthesia clinical sites by the anesthesia department directors at each facility and resulted in a 15% response rate ($n = 12$). The pretest, educational materials, and posttest were intended to be sent to any qualified anesthesia provider with the title CRNA, physician anesthesiologist, and/or SRNA. The final sample consisted of only CRNA participants with experience in providing anesthesia care that ranged from less than one year to greater than 20 years (Figure 3).

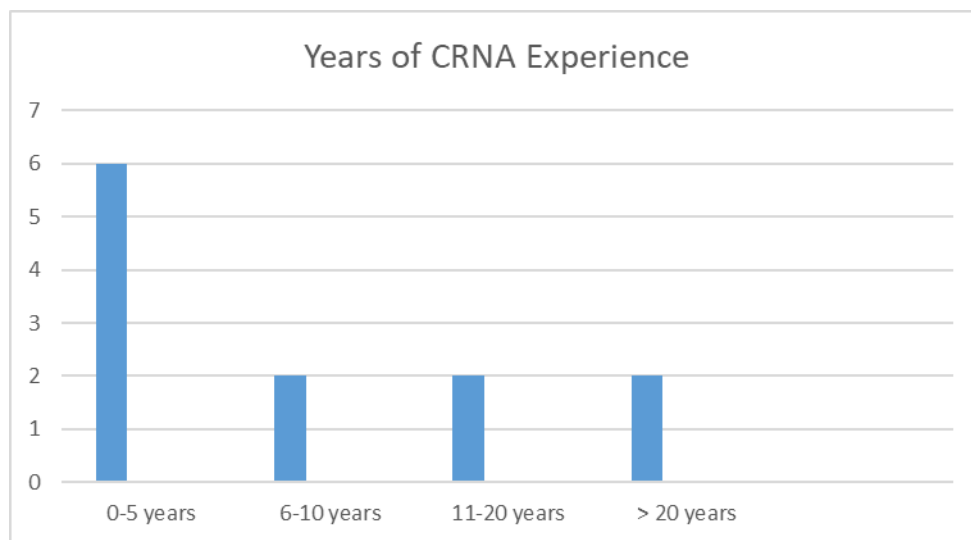


FIGURE 3. Years of experience of respondents.

Responses to Specific Project Questions

Respondents were asked five questions for comparison before and after an educational presentation on neuromuscular function assessment practices. These five questions examined

methods used for assessment, perceptions of best practice methods, presence of postoperative residual paralysis/weakness, and reversal agent administration practices. The posttest included questions regarding the respondent's likelihood the change their practice habits and perceived barriers to practice change.

Project Question 1

Which method do you use to determine status of neuromuscular blockade? Respondents cited conventional nerve stimulators as the most frequently cited method ($n = 11$) in both the pretest and posttest (Figure 4). There was no difference between samples.

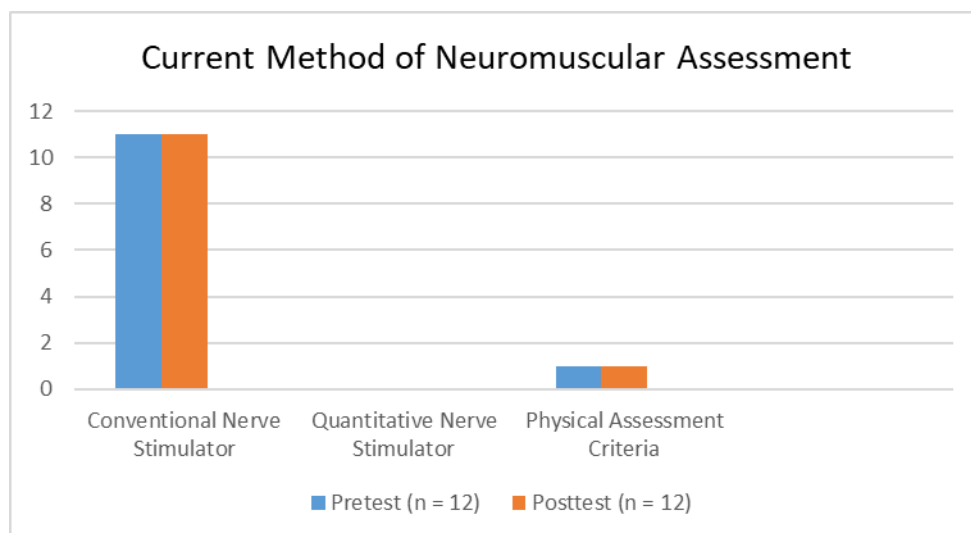


FIGURE 4. Respondents methods of determining status of neuromuscular blockade.

Project Question 2

Which method do you feel is the best to monitor for paralysis/weakness? There was no significant difference in pretest and posttest scores ($Z = 1.089$, $p = .276$). However, examination of the raw data revealed that fewer respondents selected physical assessment criteria as the best method to monitor for paralysis/weakness after reviewing the educational material (Figure 5).

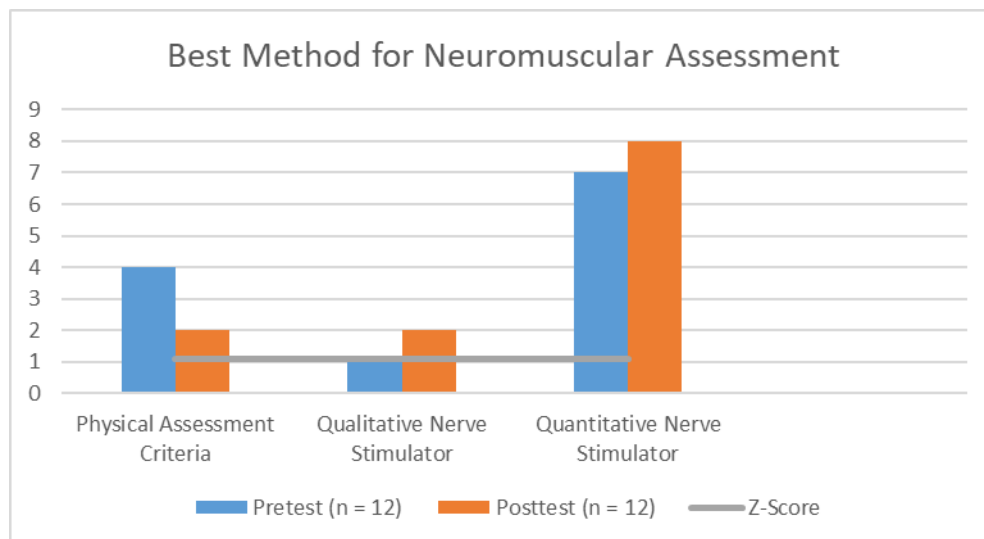


FIGURE 5. Respondents perception of the best method of neuromuscular assessment.

Project Question 3

Is postoperative paralysis/weakness a problem? Respondents were asked to answer a Likert scale question regarding their perceptions of whether postoperative residual paralysis is a problem; responses ranged from strongly disagree to strongly agree. There was a significant difference between pretest and posttest data ($Z = 2.27$, $p = 0.023$). The pretest revealed that multiple respondents strongly disagreed, disagreed, or neither agreed nor disagreed that postoperative residual paralysis/weakness was a problem. The posttest results showed respondents mostly agreed or strongly agreed that postoperative residual paralysis/weakness is a problem (Figure 6). The Wilcoxon Signed Rank test indicated that the posttest ranks were statistically and significantly higher than the pretest ranks in favor of respondents strongly agreeing that postoperative residual paralysis/weakness is a problem.

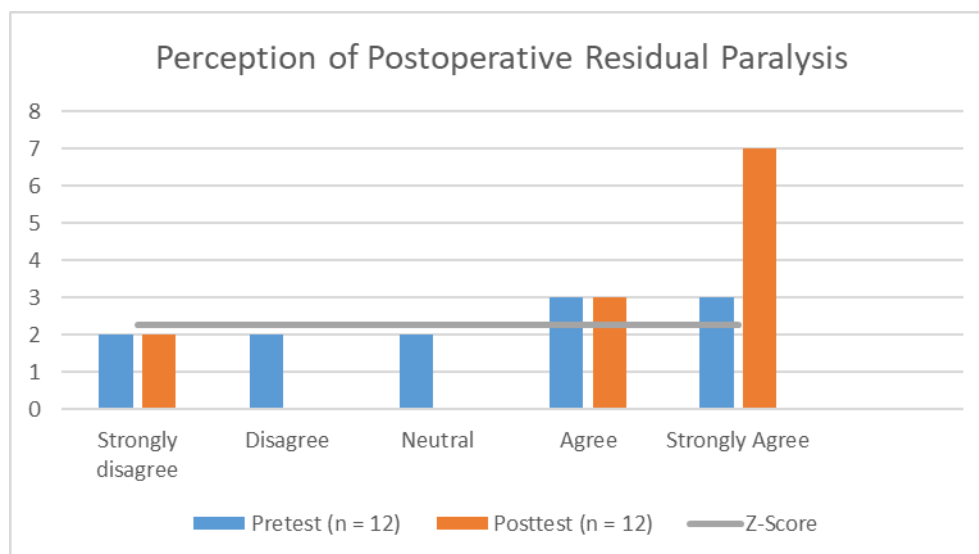


FIGURE 6. Respondents perception of postoperative residual paralysis/weakness.

Project Question 4

What site do you feel is best to monitor peripheral nerve response for recovery from neuromuscular blockade? The pretest and posttest data were unchanged, and all respondents chose the ulnar nerve as the best site to monitor for recovery of neuromuscular function when using a peripheral nerve stimulator.

Project Question 5

What rationale do you believe is the most reliable method for determining if you need to administer or can omit a reversal agent? A statistically significant difference was found between pretest and posttest data ($Z = 2.00$, $p = 0.046$), respondents favored train-of-four ratio as the best method to guide reversal agent administration or omission after the educational presentation. Prior to reviewing the educational presentation, 41.7% of respondents ($n = 5$) believed that physical assessment criteria were the most reliable method to determine dosing or omission of reversal agents for neuromuscular blockade; 41.7% ($n=5$) selected train-of-four ratio using an acceleromyographic monitor as the most reliable method. The posttest responses revealed that

only 8.3% ($n = 1$) of respondents believed that physical assessment criteria were reliable for reversal agent administration or omission; 75% ($n = 9$) stated that quantitative, Train-of-four ratio data was the most reliable method (Figure 7).

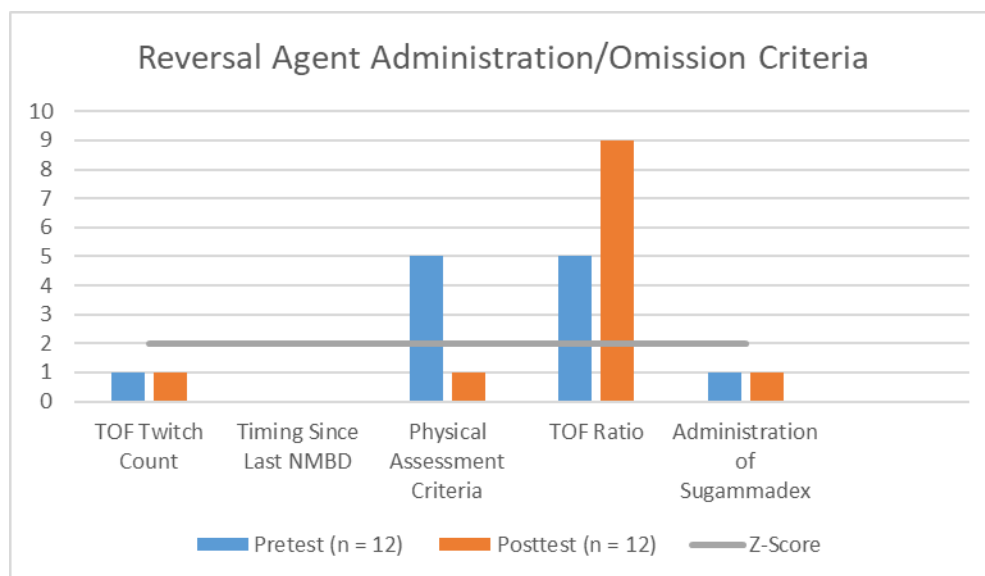


FIGURE 7. Respondents rationale for administration or omission of reversal agents

Project Question 6

How likely are you to change your practice habits in the future? Most participants responded that they were very unlikely ($n = 1$), likely ($n = 1$), or neutral ($n = 5$) when asked about their intent to change their practice habits. Participants that responded that they were likely to change their practice represented 41.67% of the sample ($n = 5$).

Project Question 7

What barriers do you perceive in changing your practice? Inadequate resources were cited most frequently as the barrier to changing practice ($n = 9$). Some respondents also believed that postoperative residual paralysis/weakness was not a problem at their facility and stated this was a barrier to changing their practice ($n = 3$).

DISCUSSION

Relationship of Results to Project Aims, Theory and Framework

The aim of this project was to increase knowledge and utilization regarding the use of a quantitative monitor for neuromuscular function recovery. This goal was partially accomplished by gaining participation in the presented project material and obtaining data that revealed significant changes in respondent's perception of the presence of postoperative residual paralysis/weakness, and the most reliable method of determining if a reversal agent should be administered or omitted. Posttest scores that were not statistically significant still indicated a change in belief that physical assessment criteria are not as reliable as using some form of a peripheral nerve stimulator to monitor for paralysis/weakness. Increasing the use of quantitative monitors as an additional aim of this project was more difficult to accomplish as the two facilities where this project was presented do not have access to quantitative monitors to neuromuscular function and this was the most frequently cited barrier to practice change. The Theory of Planned Behavior suggests that behavioral intention is predicted by attitudes, subjective norms, and perceived behavioral control. Most respondents reported neutral or likely to change their practice habits and that barriers to practice change were inadequate resources. The lack of resources is an external factor in a persons' perceived control to carry out a behavior, in this case, a practice change. The PARIHS framework encompasses three elements: evidence, context, and facilitation. The evidence that was presented was evidence based, applicable to practice, and congruent with the clinical experience of most providers. The context of the project material was relevant to anesthesia practice, and the proposed change fit with organization. However, facilitation would prove to be difficult due to lack of resources and provider attitudes

about the proposed change. There were respondents that still believed that physical assessment criteria and qualitative peripheral nerve stimulators were superior to quantitative monitoring to assess neuromuscular function and some that even believed that postoperative residual paralysis/weakness was not a problem.

Impact of Results on Practice Change

The results of this project proved that there was agreement that quantitative monitoring is a superior method to assess for neuromuscular function recovery when compared to subjective criteria such as physical assessment parameters and conventional peripheral nerve stimulators. However, inadequate resources and provider attitudes toward change may present as barriers to sustainability of practice change. Some respondents still strongly disagreed that postoperative residual paralysis was a problem and stated that they were unlikely to change their practice in the future. One of the clinical sites that participated in this survey administers Sugammadex regularly for reversal of neuromuscular blockade and this may be a possible reason to believe that postoperative paralysis is not a significant problem and why practice change may not be achieved. Sugammadex is a selective paralytic drug binding agent that is able to reverse a shallow or profound aminosteroid induced neuromuscular blockade to a TOFR greater than 0.9 within three minutes (Naguib, 2015).

Strengths and Limitations

Strengths of this project include the flexibility for participation, project materials were sent electronically, and participants could review the material and respond at time convenient for them. The total participation time was less than 30 minutes.

Limitations of this project were the smaller sample size, a total of 12 responses were able to be used for analysis. There was only a one-week timeframe allotted for participation. The project material was sent to two facilities that do not have access to quantitative peripheral nerve stimulators; data from facilities that have access to both conventional and quantitative monitors may have provided valuable information regarding providers practice habits and attitudes when assessing neuromuscular function recovery. The length of the project did not allow to assess for actual changes in practice.

Dissemination and Implications for Future Practice

The project was presented at the Arizona Association of Nurse Anesthetists Sun and Fun conference March of 2019 except for the results as the project was not complete. The results of the project will be shared by means of an executive summary (Appendix H) with the two facilities where the material was presented. Implications for future practice would be to influence practice change by gaining stakeholder interest in a more effective method for monitoring neuromuscular function recovery and ideally lead to the use of quantitative monitoring at these facilities.

DNP Essentials

The DNP essentials that have been met are essentials I, II, III, and VIII.

DNP essential I is the application of scientific underpinnings to practice. This essential was met by synthesizing evidence-based research and applying it to practice by educating anesthesia providers about neuromuscular monitoring techniques. The Theory of Planned Behavior and the PARIHS framework were the scientific underpinnings used to apply this project to practice.

DNP essential II is the application of organizational and systems leadership for quality improvement and systems thinking. This essential was met by collaborating with the anesthesia department leadership at two clinical sites to disseminate my project materials to improve neuromuscular assessment practices of anesthesia providers.

DNP essential III is the application of clinical scholarship and analytical methods for evidence-based practice. This essential was met by synthesizing evidence-based research to prepare a scholarly educational presentation about neuromuscular monitoring practices in anesthesia care.

DNP essential VIII is the application of advanced practice competencies. This essential was met by discovering a problematic issue with observed anesthesia practices in the clinical setting and then disseminating information regarding advanced health assessment techniques in the field of anesthesia.

APPENDIX A:
APPRAISAL OF EVIDENCE

Meta-Analysis			
<i>Studies</i>	<i>Evidence Supporting Hypothesis</i>	<i>Counterevidence Against Hypothesis</i>	<i>Conclusions</i>
<p>Naguib et al. (2007)</p> <p>Hypothesis: Intraoperative neuromuscular monitoring reduces the incidence of postoperative residual paralysis (PORP)</p>	<p>Studies using qualitative peripheral nerve stimulators (PNS)</p> <ul style="list-style-type: none"> • Shorten et al. (1995) <ol style="list-style-type: none"> a. Recovery was greater after administration of neuromuscular blocking drugs (NMBD) when Train-of-four (TOF) monitoring was used • Fruergaard et al. (1998) <ol style="list-style-type: none"> a. TOF ratio (TOFR) was significantly higher in the monitored group after tracheal extubation compared to clinical criteria alone • Ueda et al. (1991) <ol style="list-style-type: none"> a. Intraoperative assessment of neuromuscular blockade using tactile evaluation of TOF response was higher compared to those assessed using clinical criteria alone <p>Studies using quantitative peripheral nerve stimulators</p> <ul style="list-style-type: none"> • Mortensen et al. (1995) <ol style="list-style-type: none"> a. TOFR was higher in the monitored group using acceleromyography (AMG) at the time of reversal • Gatke et al. (2002) <ol style="list-style-type: none"> a. Residual block can be minimized using AMG monitoring • Baillard et al. (2005) <ol style="list-style-type: none"> a. After departmental education on the use of AMG monitoring, the use of this type of monitoring rose from 2% to 60%; the use of reversal agents rose from 6% to 42%; the incidence of PORP decreased from 62% to < 4% 	<p>Studies using qualitative peripheral nerve stimulators</p> <ul style="list-style-type: none"> • Pedersen et al. (1990) <ol style="list-style-type: none"> a. The use of a PNS had no effect on the PORP • Fawcett et al. (1995) <ol style="list-style-type: none"> a. PORP was not decreased when PNS were used • Hayes et al. (2001) <ol style="list-style-type: none"> a. The use of intermediate acting NMBDs does not decrease PORP b. PORP was not significantly less when PNS were used • McCaul et al. (2002) <ol style="list-style-type: none"> a. The use of PNS did not lead to adequate recovery at time of tracheal extubation 	<ul style="list-style-type: none"> • The use of PNS can guide the provider on incremental dosing of NMBDs, appropriateness of recovery and subsequent tracheal extubation • Clinical criteria alone are inferior to the use of PNS in assessing the degree of neuromuscular blockade • Multiple studies identified an attempt to reverse a profound block by using just a TOF count instead of a TOFR, which can only reliably be obtained using a quantitative PNS • Multiple studies that negate the hypothesis did not have a constant method of anesthesia delivery including the choice of NMBDs, the use of monitors (even when made available to all clinicians), and no mention of a clinical decision-making protocol regarding monitoring or reversal • The meta-analysis is greater than 10 years old and does not specifically evaluate quantitative monitoring
Randomized Controlled Trial			
<i>Studies</i>	<i>Evidence Supporting Hypothesis</i>	<i>Counterevidence Against Hypothesis</i>	<i>Conclusions</i>
Piccioni et al. (2014)	<ul style="list-style-type: none"> • There was not a complete stabilization period for AMG calibration; the sample size was 	<ul style="list-style-type: none"> • Maximum inspiratory pressure (MIP) & maximum expiratory pressure 	<ul style="list-style-type: none"> • AMG TOFR of 1.0 excludes NMBD induced respiratory muscle weakness;

Hypothesis: If clinically relevant residual concentration of rocuronium is present at an AMG TOFR of 1.0, administration of sugammadex will improve respiratory muscle function	small; respiratory tests were performed twice (three times is the recommendation)	(MEP) did not improve after sugammadex administration when compared to placebo concluding that if respiratory muscle weakness was attributable to NMBDs, sugammadex would improve these measurements	limited amount of studies to replicate this finding; small sample size (n = 20)
Murphy et al. (2011) Hypothesis: AMG monitoring will reduce the number of patients with a TOFR < 0.9 and associated symptoms of PORP	<ul style="list-style-type: none"> • The incidence of patients with TOFR < 0.9 is significantly lower in the AMG group compared to those monitored with a conventional qualitative PNS • Patients monitored with AMG have significantly less overall weakness and symptoms of muscle weakness 	<ul style="list-style-type: none"> • AMG monitoring is more accurate with calibration prior to NMBD administration <ul style="list-style-type: none"> a. TOFR are likely reflected as higher with a single post anesthesia measurement in this study 	<ul style="list-style-type: none"> • AMG monitoring proves to be superior to qualitative PNS in detecting PORP • Despite patients having a normal subjective assessment of qualitative measures, patients that did not receive reversal agents had more critical respiratory events • The use of subjective assessment measures is not a reliable indicator of PORP
Sauer et al. (2011) Hypothesis: Patients with PORP will have a higher incidence of critical respiratory events, n = 114, P < 0.05	<ul style="list-style-type: none"> • 39.5% of patients extubated with a TOFR < 1.0 had significantly more critical respiratory events, defined as an arterial oxygen saturation of < 93%, when compared to those with a TOFR of 1.0 (P = 0.021) • Patients were randomized to a placebo group or neostigmine reversal group <ul style="list-style-type: none"> a. The trachea was extubated at a TOFR of 1.0 in the neostigmine group b. The average TOFR at the time of tracheal extubation in the placebo group was 0.7 (P < 0.001) • Patients in the control and placebo group had normal responses to qualitative TOF stimulation and double burst stimulation (DBS), defined as a lack of fade, and additionally an AMG TOFR < 1.0 prior to randomization at the end of surgery after a NMBD was administered <ul style="list-style-type: none"> a. In the absence of a subjective fade with qualitative TOF stimulation and DBS, a clinician cannot distinguish a TOFR consistent with PORP (TOFR < 1.0) • AMG monitors were calibrated prior to 		

	administration of NMBDs		
<p>Murphy et al. (2008)</p> <p>Hypothesis: The use of AMG monitoring reduces the risk of PORP and the incidence adverse respiratory events in the post anesthesia care unit (PACU), n = 179, P < 0.01</p>	<ul style="list-style-type: none"> • A significantly lower number of patients presented to PACU with PORP when monitored with AMG than those monitored with qualitative TOF monitoring, 4.5% and 30% respectively (P < 0.0001) • A significantly higher incidence of severe PORP was present in the qualitative TOF group compared to the AMG group, 13.3% and 0% respectively (P < 0.001) • Patients in the qualitative TOF group developed more episodes of severe hypoxemia, defined as a pulse oximetry of < 90%, and occurrences of airway obstruction, 21.1% and 11.1% respectively compared to the AMG group that had 0% for both measures (P < 0.002) • The incidence, severity, and duration of hypoxemia within the first 30 minutes in PACU were significantly less in the AMG group (P < 0.0001) 	<ul style="list-style-type: none"> • The current standard to quantify residual block is mechanomyography (MMG) and AMG values are not interchangeable <ul style="list-style-type: none"> a. An uncalibrated AMG TOFR of 0.97 corresponds to a MMG value of 0.9 • AMG values were monitored in the PACU in an awake patient which may have reduced the accuracy of the reading 	<ul style="list-style-type: none"> • Quantitative neuromuscular monitoring is superior to subjective qualitative measures • Even though an uncalibrated AMG monitor can produce a false high TOF reading, patients have a TOFR < 0.9 less frequently when AMG monitoring is used and the risk of developing critical respiratory events is also reduced
Cohort Studies			
<p>Bhananker et al. (2015)</p> <p>Comparison of TOF count by anesthesia providers versus count using TOF-Watch SX (AMG monitor), n = 75, 687 observations collected</p>	<ul style="list-style-type: none"> • There was agreement between provider subjective assessment and TOF-Watch SX 56% of the time (386 observations) <ul style="list-style-type: none"> a. Of these agreements, 87% were at TOF counts of 0 and 4 • At TOF counts of 1, 2, and 3 the agreement was only 36% (409 observations) <ul style="list-style-type: none"> a. Provider subjective assessment revealed a higher TOF count in 96% of these disagreements (254 observations) and a lower TOF count in 4% (10 observations) • Dosing and timing guidelines for reversal of NMBDs is based on TOF count from an AMG monitor which concludes that subjective assessment of TOF count may result in inadequate dosing or inappropriate timing of reversal agents 	<ul style="list-style-type: none"> • TOF-Watch SX was used without calibration 	<ul style="list-style-type: none"> • There is a frequent lack of concordance between a provider's subjective assessment and quantitative assessment <ul style="list-style-type: none"> a. Subjective assessment often over estimates recovery from paralysis

Fortier et al. (2015) Investigation of the incidence and severity of PORP defined as a TOFR < 0.9 at tracheal extubation and at arrival to PACU	<ul style="list-style-type: none"> Anesthesia providers were permitted to assess the degree of neuromuscular block using qualitative TOF monitors or clinical criteria only Patients were assessed for this study using the TOF-Watch (AMG monitor) and all anesthesiologists and nurses were blinded to the values The incidence of PORP at tracheal extubation was 63.5% and 56.5% at arrival to PACU (all results falling within the 95% confidence interval) Qualitative TOF monitors were not used with every patient <ol style="list-style-type: none"> There was a slightly lower incidence with qualitative monitor used 51.1% vs 67.1% 	<ul style="list-style-type: none"> The TOF-Watch was not calibrated before neuromuscular block was administered The use of reversal agent did not result in a reduction in the incidence of PORP 	<ul style="list-style-type: none"> The conduct of anesthesia was not standardized Patients continued to have PORP at time of tracheal extubation and arrival to PACU despite assessment of qualitative measures Some clinicians do not use qualitative TOF monitors suggesting that they may not find value in their use
Pietraszewski et al. (2013) Observation of the incidence PORP in elderly patients after general anesthesia and rocuronium administration, n = 415, P < 0.05	<ul style="list-style-type: none"> Patients were considered recovered from neuromuscular block based on clinical indicators alone (5 second head lift, sustained firm hand grip or tongue protrusion, and effective cough) Neuromuscular monitoring was prohibited intraoperatively Patients did not receive a reversal agent and were only allowed to recover spontaneously TOFR < 0.7 was present in 31% of all patients (P < 0.05), most frequently in those 65 years old or older, 44% in that age group. TOFR was monitored using an AMG monitor 17.9% of patients 65 or older and 8.2% of patients < 65 years old experienced hypoxemia and required ventilation support (P < 0.05) 		<ul style="list-style-type: none"> Clinical criteria alone are inadequate in detecting PORP Neuromuscular monitoring is obligatory The use of reversal agents is prudent and best guided by an accurate assessment of TOFR
Survey			
Videira et al. (2011) Evaluation of what rules of thumb clinicians use to decide whether to antagonize nondepolarizing NMBDs at a hospital in	<ul style="list-style-type: none"> The most frequently used rules of thumb used for administering a reversal agent were a short interval of time since the last NMBD was administered and the presence of an inadequate breathing pattern, 73% and 71% respectively Clinicians considered the presence of PORP to be higher in their colleagues practice as 		<ul style="list-style-type: none"> This is a relatively small sample and it is representative of practices in developing country where technology may not be as readily available

Brazil, n = 86	<p>compared to their own</p> <ul style="list-style-type: none"> • The hospital's PORP was estimated to 41% based on an evaluation of 61 patients using AMG monitoring 		
<p>Naguib et al. (2010)</p> <p>Evaluation to determine attitudes about and the use of NMBDs and neuromuscular monitors amongst anesthesia practitioners in the United States and Europe</p>	<ul style="list-style-type: none"> • More U. S. respondents reported never observing PORP after administering NMBDs than European respondents, 88.1% vs 78.6% • More U. S. respondents estimated the incidence of clinically significant PORP as < 1% than European respondents, 64.1% vs 52.2% • U. S. and European respondents similarly responded that PORP is a significant anesthetic complication • The majority of U. S. and European respondents believe that the routine use of any type of TOF monitor would decrease the incidence of PORP (80% and 85% respectively) • European respondents reported that they had more access to quantitative TOF monitors than their U. S. counterparts, 70.2% vs 22.7% <ul style="list-style-type: none"> a. Monitors were more likely to be available 1 per operating room in Europe b. 77.3% of U. S. respondents reported that quantitative monitors are not available in their department • When both quantitative and qualitative monitors are available, European clinicians were more likely to use quantitative monitoring (53.2% vs 18.8%). U. S. clinicians were more likely to use qualitative monitors (63.2% vs 17.1%) • Respondents from both the U. S. and Europe agreed that sustained response to sustained tetany does not exclude residual neuromuscular weakness (78.5% and 77.7% respectively) • More respondents from the U. S. reported that clinical signs are reliable indicators of adequate neuromuscular recovery than their 		<ul style="list-style-type: none"> • The problem of PORP is reported as a significant clinical complication but respondents seem to far underestimate its occurrence • Despite the results that 80% of U. S. respondents believe the use of some type of TOF monitor would decrease the incidence of PORP; 68.2% of the U. S. respondents reported that clinical signs are indicators of adequate neuromuscular recovery • Most clinicians cannot detect fade once the TOFR reaches 40% when using subjective tactile assessment (Brull, 2017) <ul style="list-style-type: none"> a. 78.9% of U.S. respondents believe the TOFR should be > 90% prior to tracheal extubation. This can only reliably be measured using a quantitative TOF monitor • Quantitative TOF monitors are not readily available in the U. S. <ul style="list-style-type: none"> a. When given the option between a quantitative and qualitative monitor, U. S. respondents still opt to use qualitative monitors. This could be due to an availability issue where there are not quantitative monitors in each operating room or possibly a lack of education on their value or training on their use.

	<p>European counterparts (68.2% vs 43.5%)</p> <ul style="list-style-type: none">• More U. S. respondents reported that the TOFR should be in the 91-100% range before tracheal extubation when compared to European respondents (78.9% vs 57.1%)		
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APPENDIX B:
PRETEST SURVEY

1. How many years have you practiced anesthesia?
 - a. 0-5 years
 - b. 6-10 years
 - c. 11-20 years
 - d. > 20 years
2. What is your role?
 - a. CRNA
 - b. Anesthesiologist physician
 - c. SRNA
3. Which method do you currently use to determine status of neuromuscular blockade?
 - a. Conventional nerve stimulator
 - b. Quantitative nerve stimulator – Stim pod or acceleromyography
 - c. Physical assessment criteria – head lift, hand squeeze, tidal volume & respiratory rate
4. Which method do you feel is the best to monitor for paralysis/weakness?
 - a. Physical assessment
 - b. Qualitative peripheral nerve stimulator using a conventional nerve stimulator
 - c. Quantitative peripheral nerve stimulator using acceleromyography
5. Is post-operative paralysis/weakness a problem?
 - a. Strongly disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly agree
6. What site do you feel is best to monitor peripheral nerve response for recovery from neuromuscular blockade?
 - a. Facial nerve
 - b. Ulnar Nerve
 - c. Neither
7. What rationale do you believe is the MOST reliable method for determining if you need to administer or can omit reversal agents?
 - a. Train-of-four twitch count
 - b. Timing since last neuromuscular blocking drug
 - c. Physical assessment criteria - head lift, hand squeeze, TV & respiratory rate
 - d. Train-of-four ratio using an acceleromyographic quantitative monitor
 - e. Administration of Sugammadex

APPENDIX C:
EDUCATIONAL POWERPOINT PRESENTATION

▲ ▲ ▲

Educational Presentation: Quantitative Neuromuscular Monitoring for Anesthesia Providers

Diana Willis, SRNA
2019



Why is this topic important?

- Post operative residual paralysis (PORP) after receiving neuromuscular blocking drugs is present in as many as 40% of cases when the drugs are administered
- Symptoms include: Airway obstruction, apnea, hypoventilation, & hypoxemia
- Results in emergent reintubation, hemodynamic instability, increased cost, pneumonia, unplanned admission to ICU, & increased length of stay

Defining Residual Paralysis

- Train of four ratio (TOFR) < 0.9
 - Can only be accurately measured with a quantitative monitor
- Three levels of neuromuscular blockade
 - Under paralyzed → train of four count 3-4/4 twitches
 - Well paralyzed → train of four count 1-2/4 twitches
 - Over paralyzed → train of four count 0/4 twitches

Current Practice Standards

- Current Gold Standard: Utilize a qualitative peripheral nerve stimulator (PNS)
- Anesthesia Patient Safety Foundation Recommendations:
 - Quantitative monitors should be available at facilities where anesthesia is administered
 - Quantitative monitors should be used in every case when NMBD are administered
 - Is this possible at your facility?

Qualitative Monitoring



Acceleromyography (AMG)



Kinemyography (KMG)



Current Practice Habits

- The majority of providers agree that TOFR should be > 0.9 prior to extubation
- Wide variability among providers
 - Qualitative VS Quantitative VS Physical Assessment Parameters
- Naguib et al. (2010) 22.7% of U. S. respondents reported having access to quantitative monitors
 - Monitors often not available in every room/shared between OR's
- When both monitors were available, qualitative PNS were used more often

Implications of Current Practice

- Facial Nerve/Orbicularis oculi muscle more resistant to NMBD
 - Best site for onset and effectiveness of surgical relaxation
- Facial nerve stimulation
 - More than one nerve may be stimulated
 - Multiple muscles twitching → erroneous TOF twitch counts
- Recovery of diaphragm/laryngeal function
 - Most accurately correlated with response to ulnar nerve stimulation
- TOF count at the eye resulted in more significant numbers of PORP

Implications of Current Practice

- Variability between examiners with qualitative TOF assessment
 - Count detection & presence of fade
- Most examiners unable to detect fade when TOFR reaches 0.4
- TOFR of 0.7
 - Beyond tactile & visual detection of fade using qualitative monitors
 - Associated with significant muscle weakness

Benefits of Quantitative Monitoring

- Quantitative monitoring
 - Permits stimulation of ulnar nerve
 - Measures response to nerve stimulation and produces quantifiable data → TOFR
- Acceleromyography is the most commonly used quantitative technique in detecting residual paralysis and more reliable
 - Compared to tactile fade to TOF, double burst 5 Hz & 100 Hz tetanic stimulation
- Accurately detects the presence of PORP that has the potential to result in critical respiratory events

Dosing of Reversal Agents

- Inadequate dosing, timing, or omission of reversal agent administration
 - Inadequacy of conventional qualitative monitoring & physical assessments
- Non Quantifiable Criteria to dose or omit
 - Total dose of NMBD
 - Timing since last NMBD dose
 - Absence of visual/tactile fade when using a conventional PNS
 - Physical assessment criteria

Dosing of Reversal Agents

Type of Monitoring		Neostigmine Dose (administer with anticholinergic)	
Qualitative	Quantitative	Ideal Body Weight (5 mg maximum)	70 kg patient
No twitch	No twitch	WAIT	WAIT
1 twitch	1 twitch	WAIT	WAIT
2-3 twitches	2-3 twitches	~50 mcg/kg	3 to 4 mg
4 twitches with fade	TOF ratio (<0.4)	~40 mcg/kg	2 to 3 mg
4 twitches without fade	TOF ratio (<0.4-0.8)	15 to 25 mcg/kg	1 to 2 mg
	TOF ratio (>0.8)	NONE	NONE

Risk Factors for Residual Postoperative Paralysis

High total dose of neuromuscular blockade (>1.5 mg/kg rocuronium; >0.4 mg/kg vecuronium)

High dose neostigmine reversal (>60 mcg/kg)

Always dose neuromuscular blockers and reversal/anticholinergic according to monitoring and clinical condition.

Sugammadex



Rocuronium & Vecuronium

- 2 mg/kg after spontaneous recovery of the 2nd TOF twitch
- 4 mg/kg after 1-2 post-tetanic twitches are achieved

Rocuronium Only

- 16 mg/kg used if a clinical need requires reversal within 3 minutes of 1.2 mg/kg of Rocuronium
- Reverses aminosteroidal neuromuscular relaxants
 - Neostigmine remains indispensable
- Time to full recovery Rocuronium versus Vecuronium (4 mg/kg)
 - Rocuronium 2-2.9 min (0.9-20.4 min)
 - Vecuronium 4.5 min (1.4-68.4 min)

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APPENDIX D:
POSTTEST SURVEY

1. Which method do you currently use to determine status of neuromuscular blockade?
 - a. Conventional nerve stimulator
 - b. Quantitative nerve stimulator – Stim pod or acceleromyography
 - c. Physical assessment criteria – head lift, hand squeeze, TV & respiratory rate
2. Which method do you feel is the best to monitor for paralysis/weakness?
 - a. Physical assessment
 - b. Qualitative peripheral nerve stimulator using a conventional nerve stimulator
 - c. Quantitative peripheral nerve stimulator using acceleromyography
3. Is post-operative paralysis/weakness a problem?
 - a. Strongly disagree
 - b. Disagree
 - c. Neutral
 - d. Agree
 - e. Strongly agree
4. What site do you feel is best to monitor peripheral nerve response for recovery from neuromuscular blockade?
 - a. Facial nerve
 - b. Ulnar Nerve
 - c. Neither
5. What rationale do you believe is the MOST reliable method for determining if you need to administer or can omit reversal agents?
 - a. Train-of-four twitch count
 - b. Timing since last neuromuscular blocking drug
 - c. Physical assessment criteria - head lift, hand squeeze, TV & respiratory rate
 - d. Train-of-four ratio using an acceleromyographic quantitative monitor
 - e. Administration of Sugammadex
6. How likely are you to change your practice habits in the future?
 - a. Very Unlikely
 - b. Unlikely
 - c. Neutral
 - d. Likely
 - e. Very Likely
7. What barriers do you perceive in changing your practice?
 - a. Resources are inadequate
 - b. Lack of support from organization or staff
 - c. Evidence is lacking to support the change
 - d. Residual paralysis is not a problem at my facility

APPENDIX E:
RECRUITMENT EMAIL

Dear Participant,

You are being asked to participate in a project regarding neuromuscular function assessment practices. Agreement to participate will involve a brief seven question pretest using Qualtrics, followed by a narrated PowerPoint presentation, and conclude with a seven question posttest using Qualtrics.

An Institutional Review Board responsible for human subjects' research at The University of Arizona reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

I would greatly appreciate your participation.

If you chose to participate in this project, it will take no longer than 30 minutes of your time. I have attached a disclosure form that explains your rights as a participant and expectations of participation. I have outlined below the sequence of attached documents for your review in the order that they are intended to be reviewed.

1. Disclosure form
2. Link to pretest
3. PowerPoint Presentation
4. Link to posttest

Please feel free to contact me with any questions, my contact information is provided below.

Sincerely,
Diana Willis
Primary Investigator
Doctorate of Nursing Practice Candidate
University of Arizona
Phone: (602)571-4863
email: dianamiller@email.arizona.edu

APPENDIX F:
DISCLOSURE FORM

University of Arizona
Disclosure Form

Project Title: Anesthesia Providers' Knowledge and Utilization of a Quantitative Monitor for Assessment of Neuromuscular Function Recovery

Principal Investigator Name: Diana Willis

The purpose of this project is to improve neuromuscular function assessment practices of anesthesia providers after administration of neuromuscular blocking drugs that are congruent with current evidence-based practice.

An Institutional Review Board responsible for human subjects' research at The University of Arizona reviewed this research project and found it to be acceptable, according to applicable state and federal regulations and University policies designed to protect the rights and welfare of participants in research.

If you choose to take part in this project, you will be asked to complete a brief seven question pretest followed immediately by a brief narrated PowerPoint presentation and a seven question posttest, to be completed immediately after the presentation. I am inquiring about your opinions regarding postoperative residual paralysis, the current practice habits you employ to monitor neuromuscular function and antagonize neuromuscular blockade. I would greatly appreciate your participation and feedback in this project.

- It will take approximately 30 minutes to complete the pretest, presentation, & posttest.
- You will not be compensated for your participation in this project
- There are no foreseeable risks associated with participating in this project
- You will receive the benefit of improved knowledge of neuromuscular monitoring techniques from your participation
- Survey responses are anonymous
- Participation is voluntary
- Refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled
- You may withdraw at any time from the project
- You may skip any question that you choose not to answer
- By participating, you do not give up any personal legal rights you may have as a participant in this

For questions, concerns, or complaints about the project, you may call Diana Willis, University of Arizona Doctorate of Nursing Practice Candidate, at (602)571-4863 &/or dianamiller@email.arizona.edu

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact the Human Subjects Protection Program at 520-626-6721 or online at <http://rgw.arizona.edu/compliance/human-subjects-protection-program>.

By submitting your surveys, you are consenting to allow your responses to be used for the purposes of this project.

APPENDIX G:
THE UNIVERSITY OF ARIZONA INSTITUTIONAL REVIEW BOARD APPROVAL
LETTER



THE UNIVERSITY OF ARIZONA

Research, Discovery
& InnovationHuman Subjects
Protection Program1618 E. Helen St.
P.O. Box 245137
Tucson, AZ 85724-5137
Tel: (520) 626-6721
<http://hgw.arizona.edu/compliance/home>

Date: April 15, 2019

Principal Investigator: Diana Lynn Willis

Protocol Number: 1904525201

Protocol Title: Anesthesia Providers' Knowledge and Utilization of a Quantitative Monitor for Assessment of Neuromuscular Function Recovery

Determination: Approved

Expiration Date: April 11, 2024

Documents Reviewed Concurrently:

Data Collection Tools: *DNP presentation.2019.ppsx*

Data Collection Tools: *Post Test.docx*

Data Collection Tools: *Pre Test.docx*

HSPP Forms/Correspondence: *Advisor Confirmation Email.pdf*

HSPP Forms/Correspondence: *application_2-5_v2018_4.kp (1).pdf*

HSPP Forms/Correspondence: *Confirmation for Scientific Review and Department Review.pdf*

HSPP Forms/Correspondence: *Willis appendix_waiver_v2019-02-25.pdf*

HSPP Forms/Correspondence: *Willis list_of_research_personnel_2-3_v2018.pdf*

Informed Consent/PHI Forms: *Disclosure Form.docx*

Informed Consent/PHI Forms: *Disclosure Form.pdf*

Other: *COI Certification Complete for 1904525201.msg*

Other Approvals and Authorizations: *Mayo.Auth.pdf*

Other Approvals and Authorizations: *StLukes.Auth.pdf*

Recruitment Material: *Recruitment email.docx*

Regulatory Determinations/Comments:

- The project is not federally funded or supported and has been deemed to be no more than minimal risk.
- The project listed is required to update the HSPP on the status of the research in 5 years. A reminder notice will be sent 60 days prior to the expiration noted to submit a 'Project Update' form.

This project has been reviewed and approved by an IRB Chair or designee.

- The University of Arizona maintains a Federalwide Assurance with the Office for Human Research Protections (FWA #00004218).
- All research procedures should be conducted according to the approved protocol and the policies and guidance of the IRB.
- The Principal Investigator should notify the IRB immediately of any proposed changes that affect the protocol and report any unanticipated problems involving risks to participants or others. Please refer to Guidance Investigators Responsibility after IRB Approval, Reporting Local Information and Minimal Risk or Exempt Research.

- All documents referenced in this submission have been reviewed and approved. Documents are filed with the HSPP Office.

APPENDIX H:
EXECUTIVE SUMMARY

Executive Summary
Anesthesia Providers' Knowledge and Utilization of a Quantitative Monitor for Assessment of Neuromuscular Function Recovery

Prepared by Diana Willis BSN, RN, SRNA

Introduction

This document summarizes the results of the project I conducted at your facility.

Objective

The purpose of this project was to improve neuromuscular function assessment practices of anesthesia providers that are congruent with current evidence-based practice. The aim was to increase knowledge and utilization regarding the use of a quantitative monitor for neuromuscular function recovery

Conclusion (Findings)

After participating in my educational presentation, anesthesia providers (CRNAs) agreed that postoperative residual paralysis/weakness was a patient safety issue and that quantitative monitoring is the best method to monitor the status of neuromuscular function. Quantitative monitoring is felt to be the most reliable method for determining if a reversal agent needs to be administered or omitted. The most commonly cited barrier to changing practice was that resources are inadequate (access to equipment/monitors).

Background

Incomplete recovery from the effects of neuromuscular blocking drugs occur in as many as 40% of cases and patients are susceptible to developing respiratory complications such as hypoxemia, hypoventilation, airway obstruction, and apnea. Residual paralysis/weakness is defined as a Train-of-four ratio of less than 0.9 and can only be reliably assessed with a quantitative monitor. Subjective assessment with a conventional nerve stimulator or physical assessment carries the risk of variability between providers and place patients at risk.

Process

Participants were asked to complete a pretest, review an educational presentation, and complete a posttest. The pretest and posttest included questions about neuromuscular function assessment practices (method, site, and reversal agents) and if postoperative paralysis was thought to be a problem.

Recommendations

My recommendations would be to incorporate quantitative monitoring into the standard of care for patients requiring muscle relaxation for surgery. The ability to quantify neuromuscular function will enable anesthesia providers to more safely care for patients in their care, ensuring that they have adequate function to prevent adverse events postoperatively.

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